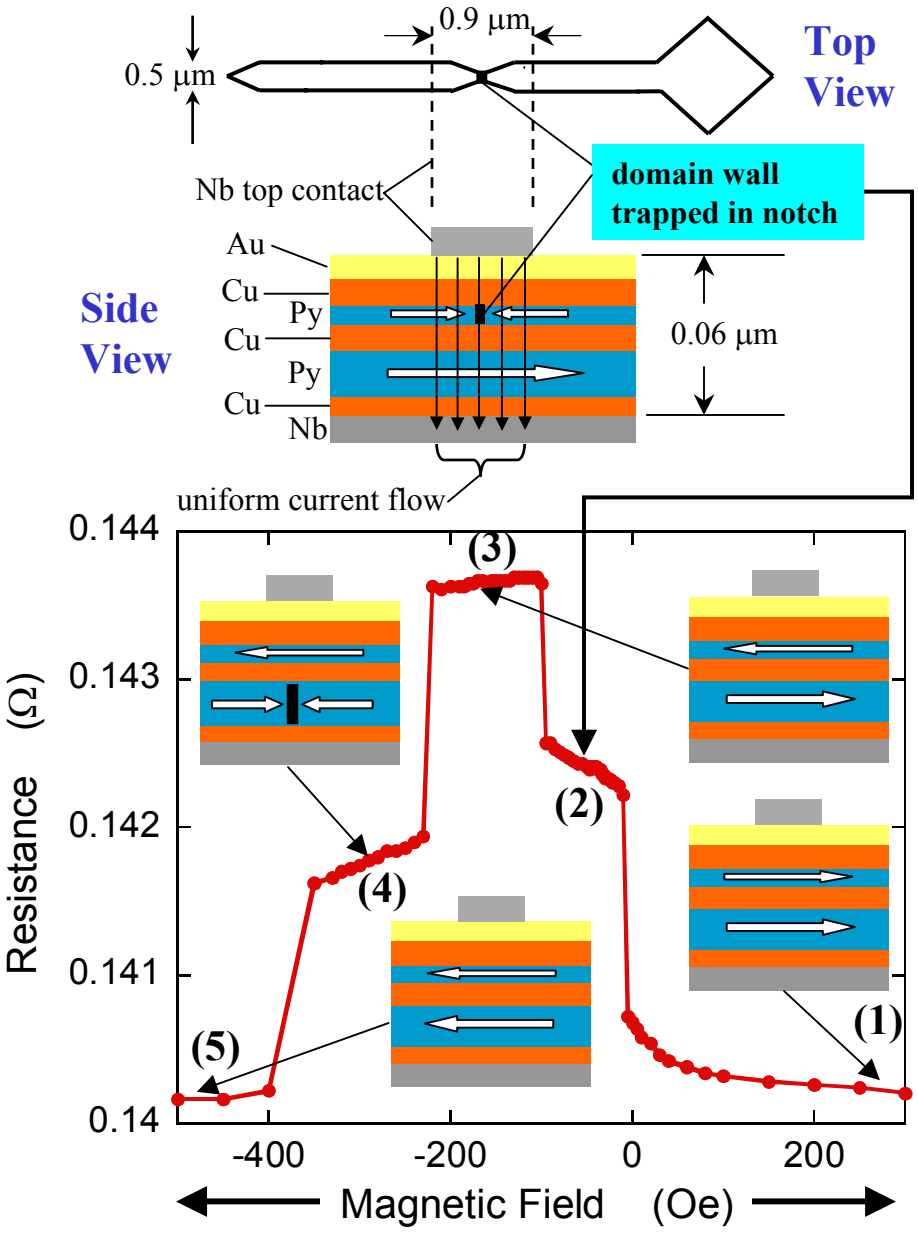
Detection of Domain Wall Trapping by Perpendicular-Current Giant Magnetoresistance

W. P. Pratt, Jr. and J. Bass, Michigan State University, DMR-0202476

Control of magnetic domains at sub-micron (< 1μm) lengths is an important issue in "spintronics" both for physics and device applications. We have developed a new method of detecting the position of a trapped domain wall with high precision, using current-perpendicular-to-plane giant magnetoresistance. The cartoon shows two views of the multilayer structure, which has two Permalloy ("Py" = $Ni_{84}Fe_{16}$) ferromagnetic layers. At low temperatures (4.2 K), the top and bottom Nb layers are superconducting, providing a uniform current confined to the notch region where the domain wall is trapped. Resistance is highest when the magnetizations of the two Py layers are antiparallel and lowest when they are parallel. When a wall is trapped in the notch of the thin Py layer, the sample is half antiparallel and parallel (see white arrows) in the current region; and slight wall motions will significantly change the resistance. The graph shows how the resistance varies as the magnetic field (parallel to sample axis) goes from + 300 Oe to – 500 Oe, causing walls to enter the 0.5-μm part of the sample from the right, get trapped in the notch and then leave.



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Technological Significance: Control of magnetic domains in sub-micron-size ferromagnets has important applications in future magnetic random access memories. Manipulation of domain walls by localized currents is one way of 'writing' such a magnetic bit. However, engineering restrictions require the localized current density for 'writing' to be a factor of ten lower than what has so far be achieved. Domain walls trapped in notches are actively being studied for such lower current 'writing.'

Education: We typically supervise one Postdoctoral student, three Ph.D. students, and undergraduates and visitors. In 2003, we hosted a female French MS student, an African-American summer REU undergraduate student, and a Korean sabbatical visitor.

Outreach and Service: One of us (JB) supervised the Physics portion of the Michigan Science Olympiad from 2000 thru 2002. We gave tours of our facilities to students taking physics and chemistry classes in local high schools. We participated in a daylong Sensors Program during Science Day at the Mall. JB is now co-chair of the physics panel for the NRC fellowship program evaluating candidates for postdoctoral fellowships for federal laboratories, and was just elected Vice-President of GMAG, the Magnetism Group of the APS. Next year he will become President Elect, the following year President, and finally, Past President during his four year commitment. WPP has been a member of the advisory board of the Magnetism and Magnetic Materials conference since 1998.

Jack Bass and William Pratt at Science Day at the Mall